Seepage Model for Performance Assessment

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RESEARCH OBJECTIVES

Seepage into drifts in unsaturated tuff is an important issue for the long-term performance of the potential nuclear-waste repository at Yucca Mountain, Nevada. The so-called Seepage Model and the Disturbed Drift Seepage Submodel and their results will be used in performance assessment (PA) to develop a probability distribution of waste seepage into waste emplacement drifts. The primary purpose is to evaluate seepage under various conditions, scenarios and parameter variations, with stochastic representations of hydrological properties, and to evaluate the effects of an alternative drift geometry representing a partially collapsed drift using the Disturbed Drift Seepage Submodel.

APPROACH

Seepage into drifts is evaluated by applying numerical models with stochastic representations of hydrological properties and performing multiple realizations of the permeability field around the drift. The Seepage Model for PA uses the distribution of permeability derived from niche tests in the Exploration Studies Facility (ESF) at Yucca Mountain, to stochastically simulate the 3-D flow of water in the fractured host rock in the vicinity of potential emplacement drifts under ambient conditions. A Disturbed Drift Seepage Submodel is developed to evaluate the impact of partial collapse of a drift on seepage.

Figure 1 is a sketch summarizing the modeling cases. The top part of the figure shows a 3-D matrix, spanned by the three parameters, which are most sensitive in affecting drift seepage — namely, fracture continuum permeability k_{FC}, van Genuchten α value and the standard deviation σ in ln k_{FC}, which is a measure of heterogeneity of the permeability field. For each combination of these three parameters, i.e., at each point, seepage model calculations were made for three realizations, using a range of values for percolation flux Q_p.

The middle part of Figure 1 indicates a study of drift seepage for three alternative permeability spatial correlation lengths, λ. This allows an evaluation of the effect of this parameter. The minimum set of parameters that describe a simple heterogeneous field are the two parameters σ and λ. Thus we investigate how seepage depends on the heterogeneous field.

The lower part of Figure 1 shows several scenarios of the Disturbed Drift Seepage Submodel. Based on a review of current information, alternative drift degradation modes are evaluated and four scenarios are identified for seepage model studies as indicated. The lower left part of Figure 1 shows the case when the percolation flux above the drift is episodic rather than at a constant average value, so that all the flux comes within a short period of time, with no flux between such pulses.

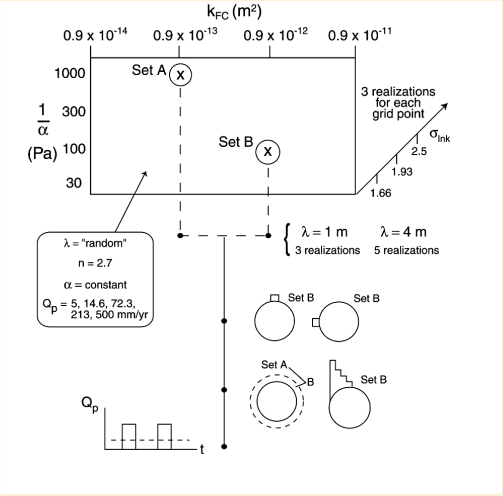

Figure 1. Different parameters varied in sensitivity studies on seepage.

ACCOMPLISHMENTS

Results show the impact of various factors on seepage and provide data for PA to develop probability distributions. Generally, seepage is calculated to be larger for smaller k_{FC}, smaller $1/\alpha$ and larger Q_p values. It is moderately sensitive to the van Genuchten parameter, n. The spread of results from the three realizations should give an indication of the geostatistical distribution. In general, the spread is large for larger λ and more limited if λ is much smaller than the drift diameter. The preliminary results for a degraded drift show that the effect of a single rock fall is not significant for seepage, whereas a deeper rock failure in the drift roof increases seepage. For the episodic percolation cases, the results indicate that average seepage will be larger than the constant flux scenario for the same annual total flux.

SIGNIFICANCE OF FINDINGS

Using a realistic 3-D heterogeneous Seepage Model and Disturbed Drift Seepage Submodel provides quantitative measures of potential seepage for the following issues: (1) alternative correlation length λ values; (2) drift disturbed zone scenario and extended failure scenario; and (3) episodic percolation flux. Such data are essential to evaluate the performance of the potential nuclear waste repository.

RELATED PUBLICATIONS

Tsang, C.F., and G. Li, Seepage model for PA including drift collapse, AMR 0075, MOL-NBS-HS-000002 Rev 00J, LBNL, 1999.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, through Memorandum Purchase Order EA9013MC5X between TRW Environmental Safety Systems, Inc., and Ernest Orlando Lawrence Berkeley National Laboratory for the Yucca Mountain Site Characterization Project under Contract No. DE-AC03-76SF00098.